

The current TCEQ UIC permit limitations require the pH of the injected waste streams to be no greater than 8.0 and no less than 4.0. Upon Petition re-issuance approval, that range will remain the same. Currently, the permit specific gravity limit of the injected fluids is equal to or less than 1.20 at 70.5 °F (surface conditions). This Petition re-issuance demonstration is made for a running three-month average of injected waste specific gravities between 1.02 and 1.07 at 60 °F/60 °F at surface pressures. Ineos will maintain the physical and chemical characteristics of the injected fluids within specified permit and Petition levels.

6.1 Waste Stream Sources

Acrylonitrile is produced using the Ineos process for ammoxidation of propylene. Propylene, ammonia and air are combined in the presence of a catalyst to form acrylonitrile, water, and co-products acetonitrile and acetone cyanide. Much of the water generated in the process is recycled to minimize make-up water and recover heat. Process wastewater, which cannot be recycled, normally exits the process as bottoms from the stripper column and bottoms from the acetonitrile column. The USEPA has designated these streams as K011 and K013 respectively. At the Green Lake facility the volume of waste produced per pound of product is reduced by process modifications that enable the recycling of the stripper bottoms.

Hydrogen cyanide, a co-product from acrylonitrile manufacturing, is converted to acetone cyanohydrin. This waste stream, which is generated at a pH of 8-9, is not reactive above pH 2.0 nor when mixed with the other injected wastewater for treatment.

Acetonitrile, another co-product from acrylonitrile manufacture, is purified into a finished product. The waste stream generated from the bottom of the acetonitrile purification column is designed by the USEPA as K014.

Periodically, caustic or acid is used to clean equipment. This potentially corrosive material can be routed to the deep-well system. These are intermittent streams with a pH that can be as high as 14.0 or below 2.0. The design flow is low (1 gpm) and therefore

when it is mixed for treatment with the other injected wastes the mixture typically has a pH of 4.0 to 8.0. When the maleic a unit is operated, maleic acid is routed to the injection well system. This is a relatively low flow stream (20 gpm) which does not significantly alter the mixture's pH.

Several additional streams that are intermittent or have such a low flow rate that they are de minimus in nature may also be routed to the deep-well system. These include ammonia blowdown, scrubber water, slop water, contaminated storm water, pump-seal water, water from the loading/unloading sump, landfill leachate, contaminated ground water, equipment wash water, and solutions which are compatible with the permitted waste streams and reservoir. Spills of commercial chemical products or their intermediates may occur and may be routed to the deep-well system. These waste streams can contain relatively small quantities of acrylonitrile, hydrocyanic acid, acetonitrile, acetone, acrylic acid, acetone cyanohydrin, and maleic acid which would be compatible with the process wastewater. The laboratory uses several chemicals which may be deep-well disposed. These chemicals include, but are not limited to the following materials:

cyclohexanone	methylacrylonitrile
acetaldehyde	methyl ethyl ketone
acrolein	methylene chloride
allyl alcohol	methyl isobutyl ketone
benzene	nitrobenzene
carbon tetrachloride	phenol
chloroform	potassium
crotonaldehyde	cyanide
ethyl acetate	pyridine
formaldehyde	sodium cyanide
formic acid	tetrahydrofuran
furfural	toluene
furan	xylene
mercury	

Other lab reagents, such as Hach's C.O.D. reagent may be toxic by characteristic. The amount of any of these lab reagents that might be disposed at any one time is less than

one quart. Disposal is infrequent and the concentration of these reagents would be less than 0.5 ppm of any of the hazardous constituents.

If Ineos determines that there is a need, a reverse osmosis unit will be installed to treat cooling tower make-up water. The non-hazardous brine reject stream from this unit may be surface water discharged or commingled with the deep-well stream for disposal.

6.2 Waste Stream Characteristics

Listed below is the 2008 range of concentrations for routinely analyzed parameters in the deepwell stream:

<u>PARAMETER</u>	<u>RANGE</u>
pH	3.8 – 7.1
specific gravity	1.02 - 1.05
cyanide (total)	244 – 1,140 mg/L
acetonitrile	1,270 – 3,500 mg/L
acrylonitrile	564 – 2,550 mg/L

While the ranges shown above adequately describe the typical deep-well stream, which is dominated by the K011 and K013 waste streams, there are brief and intermittent periods (i.e., periods of heavy rainfall, plant turnarounds) where the waste may be dominated by storm water or wash waters. In these instances, concentration of organics decline, specific gravity decreases, pH may vary between 4.0 and 8.0 standard units, and flow is significantly lower.

The following table provides a range in concentration and physical parameters for various components of the composite waste stream injected into the existing injection wells during 2008. These ranges are based on monthly grab samples collected during 2008 to determine average constituent concentrations. Appendix H includes a spreadsheet of these twelve laboratory analyses of the composite waste stream that is injected into the Ineos wells.

conservative for lateral plume movement for all petitioned constituents. This CRF is used to model the extent of the injectate plumes at the end of projected operations and for the 10,000-year post-operational timeframe.

6.4 Compatibility

Wastewater to Injection Zone Compatibility

Formation fluid compatibility has been historically demonstrated for the fluids injected at the Ineos Green Lake facility. The successful injection of wastewater for more than 24 years of continuous operation demonstrates the compatibility of the injected wastewater and the formation fluids and formation matrix. The future proposed waste stream is identical to the existing waste stream, with the exception being a possible increase in the amount of ammonium sulfate or other salts present in the waste stream. This increase should not present any formation fluid to waste incompatibility.

Ineos has many years of experience in handling the waste stream which is disposed of at the Green Lake site. The various streams do not react noticeably when mixed. The various waste streams discussed previously in this section are mixed at the beginning of the deep-well pre-treatment surface facilities. The combined stream is thoroughly filtered prior to injection to remove any precipitates that might be generated. Suspended solids, pH, and specific gravity are monitored closely to maintain the injectivity of the injection strata. The reactions of wastewater with formation fluids were investigated by a core flow study in 1984. The tests were run using the facilities deep-well waste stream and a synthetic formation fluid whose composition was based on connate water recovered during construction of WDW-163. The synthetic brine composition was:

sodium	28,130 mg/L
calcium	2,160 mg/L
magnesium	220 mg/L
barium	16 mg/L
potassium	150 mg/L
strontium	272 mg/L
chloride	50,700 mg/L
bicarbonate	177 mg/L
sulfate	87 mg/L

No known reactions take place between the components of the injection water and the connate waters except the reaction between calcium and the sulfate ions producing calcium sulfate. Because each Ineos well was buffered prior to initial injection of wastewater, the reaction was prevented from occurring within the immediate vicinity of the wellbore. As the waste front expanded, the buffering fluid would not continue to separate the fluids. As the initial concentration of calcium and sulfate ions reached saturation levels, precipitation would begin. Meanwhile, the fluid could continue to sweep further away from the wellbore. Any precipitation which occurred at a distance of 25 feet or more from the wellbore, would have no observable effect on well performance. The amount of precipitate would be small since the leading edge would continue to provide an additional buffer as the calcium sulfate precipitated. Also, limited contact of calcium and sulfate ions, due to the limited mixing ability in interstitial pore spaces, would reduce the impact of the precipitate formation. No other constituents of the wastewater have any known reactivity with formation fluids.

Complete petrographic analysis of the three Injection Interval cores indicates that the intervals are composed primarily of quartz, with lesser amounts of feldspars, calcite, and clay minerals. Quartz sand is very inert and will only react with very aggressive chemicals such as hydrofluoric acid. The wastewater does not contain any of these aggressive chemicals.

The clays identified in the core analyses are kaolinite and smectite in the 5,612-foot to 5,613-foot core; and montmorillonite, kaolinite chlorite, illite and mica in the 6,968-foot core. These clay minerals do not chemically react with the organic or mineral components of the wastewater. However, some clay minerals such as montmorillonite can be affected during the injection of storm water, which lacks ionic content. When contacting the clay, the fresh water will be drawn in, causing the clay to swell. This physical reaction results in significant reduction of permeability for an injection well. However, this effect is generally reversible and will have no long-term effect on injection. One other possible reaction is the absorption of organics on the surface of clay. This is a

physical, not a chemical reaction. The clays having a slightly polar nature can attract polar organics and cause the molecules to adhere to the clay surface. There is no physical or chemical transformation of either clay or organic molecules.

There is no significant reaction between the injection fluid and feldspar. The microscopic analyses of the cores indicate that the feldspar is present in the form of overgrowths, which are the results of solubilization and re-deposition of feldspar from earlier water reactions. It is assumed that such reactions will continue. This will have no significant effect on the formation due the limits of the solubility and the amount of feldspar available (feldspar makes up to 15 percent - 35 percent of the Injection Interval matrix).

The wastewater may react with the calcite which is found in the 6,968-foot zone core analysis. The slightly acidic characteristic of the wastewater may cause the calcite (calcium carbonate) to solubilize on the crystal surface and re-precipitate as calcium sulfate. If the calcite is present as very small, widely distributed crystals, then there can be a decrease in permeability because the re-precipitated calcium sulfate molecule is large and tends to deposit crystals on the surface of sand-size granules, binding them together and restricting passage of fluid. In the instance of large crystals or layers of calcite, the reaction has very little effect because the surface area is very small in comparison to the volume it occupies and once the surface molecules react with the sulfate, the calcium sulfate crystals produced are inert to further reaction with wastewater or sulfate ions.

The Confining Zone, like the Injection Zone, is of Oligocene age. Reactions between the deep-well wastewater and the sands and shales of the Confining Zone would therefore be similar to those described above. In addition, the Confining Zone connate water would be expected to have similar properties (saturated brine) to the Injection Zone formation fluid since the fluids would have been placed within the sedimentary matrix within the same geologic time span. The formation fluid/wastewater mixture, has been tested as previously described and was found to be un-reactive.

Ineos may in the future expand its production capabilities at the Green Lake facility. If the expansion adds any new waste streams, the amount of ammonium sulfate or other salts present in the injected waste stream may increase due to the wastes generated by proposed manufacturing units. The currently injected wastestream contains about 4 percent to 6 percent ammonium sulfate. However, increasing the amount of ammonium sulfate in the waste stream is not expected to have any detrimental or negative impact on the formation matrix and/or formation fluid. Compatibilities between the formation matrix and formation fluid are expected to be similar to those presented in the previous paragraphs.

Wastewater to Materials of Construction Compatibility

Ineos has operated WDW-163, WDW-164 and WDW-165 injection wells for 26+ years. During that period, no evidence of waste stream-to-cement incompatibility has ever been observed. In addition, Ineos conducts quarterly corrosion monitoring using carbon steel and stainless steel coupons similar to those from which the subject injection wells are constructed. Corrosion rates for carbon steel are low. No corrosion has been observed in association with the stainless steel coupons. These results indicate that the tubulars used in the construction of the well are appropriate and compatible with the currently injected waste stream.

Ineos currently conducts corrosion monitoring to determine corrosion rates for the carbon steel and stainless steel from which the injection well tubulars and screen are constructed. Two types of corrosion coupons (stainless and carbon steel) are continuously exposed to Ineos deep-well injectate. These coupons are evaluated on a quarterly basis according to Underground Injection Control (UIC) guidelines and the results are submitted to the TCEQ with the Quarterly Injection reports. The currently injected wastewater has caused no perceptible degradation or corrosion of the stainless steel coupons. The carbon steel coupons exhibit some evidence of crevice/pitting corrosion. The average rate of corrosion for the carbon steel coupons for the previous twelve years is as follows: 1997 – 5.55 mils/year; 1998 – 8.68 mils/year; 1999 – 6.92 mils/year; 2000 – 3.40 mils/year; 2001

– 1.60 mils/year; 2002 – 1.04 mils/year; 2003 – 1.6 mils/year; 2004 – 4.3 mils/year; 2005 – 0.7 mils/year; 2006 – 1.6 mils/year; 2007 – 0.6 mils/year; and 2008 – 1.9 mils/year;. Ineos has concluded that this corrosion is within industry standards and does not compromise the mechanical integrity of the deep-well system.

Given the results of the annual annulus pressure testing and the results of the corrosion monitoring data, it can be concluded that the existing injection wells are mechanically sound and have not been affected by any unusual or excessive corrosion. It is anticipated that the current long string and injection tubulars should be able to withstand corrosive effects of the currently injected waste stream and subsurface environment for the life expectancy of the injection wells.